



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

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International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 9, September 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 7.569



# Seismic Analysis of Multi-Storey Building in Different Seismic Zones Using Response Spectrum Method

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**ABSTRACT:** In India, multi-storied structures region part sometimes generated because of more value and insufficient of land. Earthquake could be an occurrence which power bring about the leading damaging forces on building. Structures ought to be produced secured for lives by accurate manner and involvement of structural member as to have a ductile sort of breakdown. To secure such civil structures from notable structural destruction, the seismic reactions of these buildings is examined accompanying wind force computations and loads such as support reactions and displacements of joint are computed and involved in the building design for a vibration resistant building. The beginning aim is to make connect earthquake resistant building by pursuit seismic study of the structure by static equivalent methods of learn and do the examination and plan of the structure by utilizing E-TABS software in static and dynamic analysis. For this cause, a G+10 residential structural plan is assessed. Seismic computations are managed for earthquake zone II, III, IV and V. The structural protection of the building is guaranteed by computing all performing force on the building, considering the lateral loads bring about due to wind and seismic incitement

**KEYWORDS:** Storey drift, Storey displacement, Base shear, Response spectrum analysis, Mode shapes, E-TABS.

## I. INTRODUCTION

Quake waves produce ground motions in larger scale on land surface when we compare with hard and rocky surface. Structures located on such lands will experience more damage in comparison to the buildings that are located on rocky surface. The human race is continuously combating with all types of natural calamities like floods, tremors, volcanic eruptions etc., all these cause massive losses to life and assets. In order to face these kinds of calamities, many technologies are being developed for example warning system for disaster, adopting prevention measures etc., Tremor occurs within no time for a few seconds and can cause any amount of loss and this depends on intensity of quake. The damage caused could be controlled to some extent if not completely keep away from. So, preventing the damage from earthquake is a universal concern today. The competition headed for new level is not possible unless the challenges are taken up. As the structure's height increases, the building being stiffer will become more important. When the number of stories is added in high raised structures, it has to face different loading conditions with relatively high loading values resulting from horizontal loads like quake forces. These are grabbing importance and every structural designer has to deal to introduce enough stability and strength against these horizontal loads. In this project, analysis is carried out using E-TABS software for a Ground + 10 storey RCC structure under seismic conditions for zone II, III, IV and V. Various load combinations are considered which are in line with IS 1893 (Part 1):2002.

## II. RELATED WORK

Quake can be considered as one among the major unexpected natural phenomena. However, most of the codes used for structural design talk about the forces produced because to inertia as a combined effect of such an unsystematic shaking in the type of equivalent static lateral forces. And this can be normally identified as seismic "DESIGN BASE SHEAR" symbolized by  $S_d$  and remains as the primary force accumulated in the force-based quake resistant structural design. This force will be dependent on the quake hazard at the location of the building. This is represented by seismic "Z", Zone Factor. Indian design codes denote this force by calling it as " $S_a/g$ " and it is termed as structural flexibility factor.

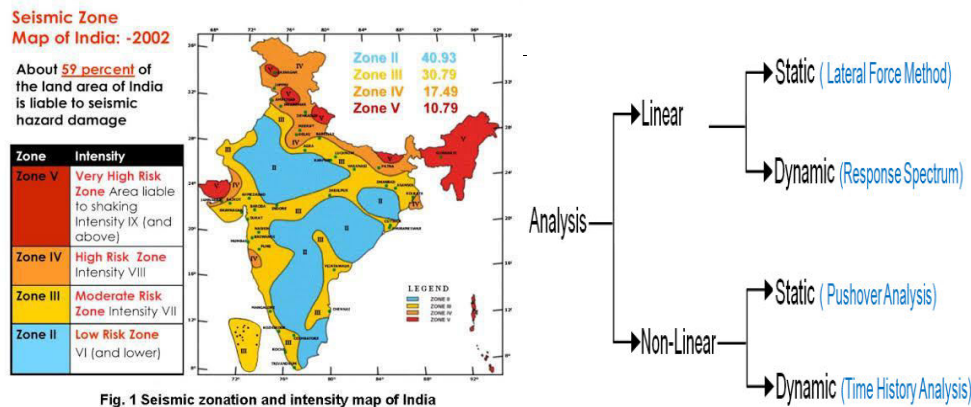


Fig. 1 Seismic zonation and intensity map of India

Fig.1

## TYPES OF ANALYSIS

The different analysis procedures are: -

- Linear Static Analysis
- Linear Dynamic Analysis
- Non-Linear Static Analysis
- Non-Linear Dynamic Analysis

## PROBLEM STATEMENT

- This is an educational building, thus the main aim on the response of the frame configuration.
- At ground floor no floor slabs are considered since this floor will be laying on the natural ground directly. However, plinth beams are taken in account to erect the walls.
- In plan the ends of beams are situated at the column's centre. To avoid eccentricity this is done. However, E-tabs will do it by default.
- For columns, beams and slabs M40 concrete grade is considered & Steel Grade of Fe 550D is used.
- Columns At footing level are provided with fixed supports.
- Quake forces are accounted only in 2 lateral directions i.e., x direction & y direction.

## III. METHODOLOGY

### Step-1: Modelling the structure:

As per the floor plans available for the building, structural framing is done using E-tabs software with the help of structural wizard.

### Step-2: Grid system creation

As per to the available architectural layout and column's locations grids will be marked in drafting software -cad then the same spacing will be used in E-tabs in X and Y directions.

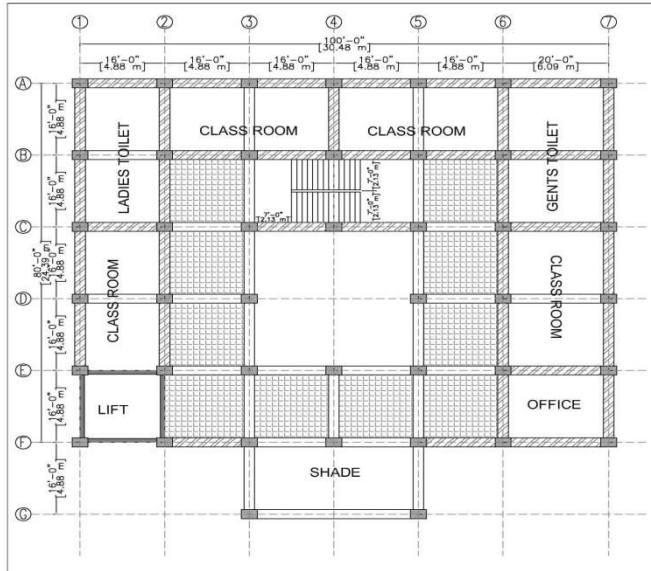
### Step-3: Defining of structural material & sectional properties:

Go to define drop down menu and define concrete grade as M40 and HYSD steel as Fe550D. Later other structural elements like beams, slabs, columns etc are generated.

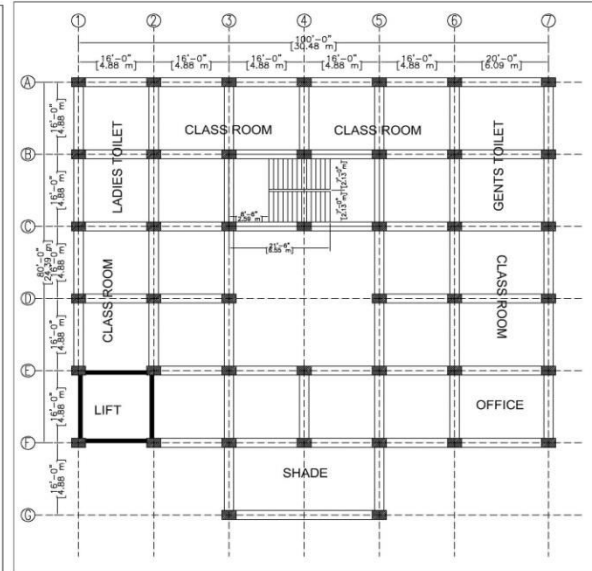
### Step-4: Generating structural model

Once the grid system is established columns will be created from foundation level to the top most floor. beam & slab members will be generated as per the structural drawings.

**Step-5: Assigning structural loads:**



**FIG.2 FLOOR PLAN WITH COLUMN & WALL LOCATION**



**FIG.3 TYPICAL PLINTH BEAM LAYOUT**

**i. BUILDING DETAILS**

- Structure = RCC (OMRF)
- Shape of structure = Rectangular
- Dimension = As shown in the figures above
- Cumulative Height of structure from its footing level
- (G+10+ Head Room) = 45.62m
- Slab to slab height: 3.96m
- In X-direction = 7 spacing of dissimilar lengths (ref above floor plan)
- In Y-direction = 6 spacing of dissimilar lengths (ref above floor plan)

**ii. MATERIAL PROPERTIES**

- Grade of concrete = M40 for footings, columns, slabs and beams
- Grade of steel = Fe550D
- Density of concrete = 25KN/m<sup>3</sup>

**iii. SECTION PROPERTIES**

- Beam size = 600mmx750mm
- Column = 600mmx900mm





- Slab Thickness = 200mm
- Wall Thickness = 200mm, 150mm

**LOAD CONSIDERATION**

- Floor Finish- 1kN/sqm, Partition wall load on slab 1kN/sqm,
- Terrace Water Proofing - 1kN/sqm
- Imposed Load - 3kN/sqm in common area; 2kN/sqm in toilet area and 1.5kN/sqm at terrace

- Main Wall Load

Density of concrete block (0.2m thk) = $17.65 \times 0.2$	= 3.53 kN/sqm
Density of Mortar (0.012+0.02 = 0.032m thk) = $20.40 \times 0.032$	= 0.65 kN/sqm
<b>Total</b>	<b>= 4.18 kN/sqm</b>
Floor to Floor height	= 4.27 m
Beam depth	= 0.75 m
Concrete Block wall height = $3.96 - 0.75$	= 3.21 m

$$\text{Main Wall Load} = 4.18 \times 3.21 = 13.42 \text{ kN/m}$$

- Partition Wall Load

Density of concrete block (0.15m thk) = $17.65 \times 0.15$	= 2.65 kN/sqm
Density of Mortar (0.012+0.012 = 0.024m thk) = $20.40 \times 0.024$	= 0.49 kN/sqm
<b>Total</b>	<b>= 3.14 kN/sqm</b>
Floor to Floor height	= 3.96 m
Beam depth	= 0.75 m
Concrete Block wall height = $4.27 - 0.75$	= 3.52 m

$$\text{Partition Wall Load} = 3.14 \times 3.52 = 10.98 \text{ kN/m}$$

- Parapet/balcony Wall Load

Density of concrete block (0.1m thk) = $17.65 \times 0.1$	= 1.77 kN/sqm
Density of Mortar (0.012+0.02 = 0.032m thk) = $20.40 \times 0.032$	= 0.65 kN/sqm
<b>Total</b>	<b>= 2.42 kN/sqm</b>
Parapet/balcony wall height	= 0.9 m

$$\text{Parapet/balcony Wall Load} = 2.42 \times 0.9 = 2.18 \text{ kN/m}$$

#### IV. EXPERIMENTAL RESULTS

##### GENRAL

This chapter addresses the findings obtained from response spectrum analysis using E-tabs software on Base reaction, storey forces, storey displacements and storey drift.

1. Base reactions in zone 2,3,4 and 5
2. Storey forces in x and y direction
3. Storey displacements in x and y direction
4. Storey drift in x and y direction

##### DEFLECTION SHAPE FOR 1.0DL + 0.8LL + 0.8RSX

##### FOR THE BUILDING IN ZONE II, III, IV, V

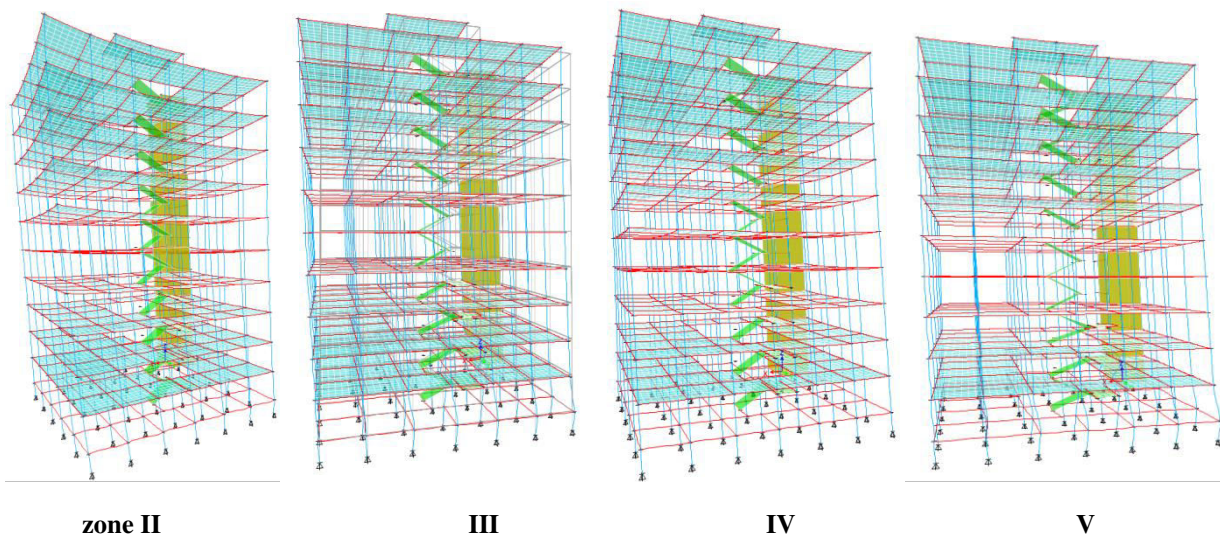


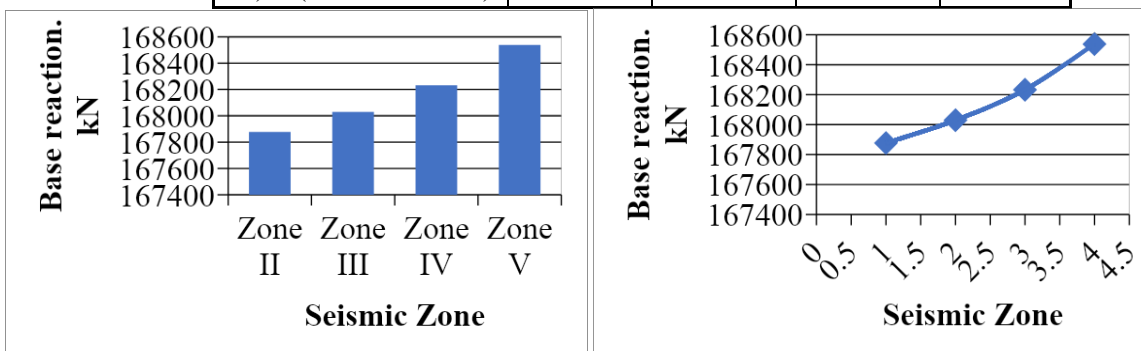
Fig.4

##### BASE REACTION FOR ALL 4 ZONES

The Base reaction obtained from modelling by Response spectrum analysis are shown in tables and graphically represented.

##### Base reaction for all 4 zones

TABLE: Base Reactions, FZ in kN				
Load Case/Combo	Zone II	Zone III	Zone IV	Zone V
02)1.2(DL + LL + RSX)	167876.86	168029.36	168232.69	168537.7

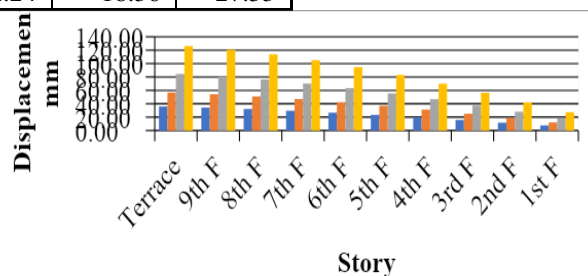
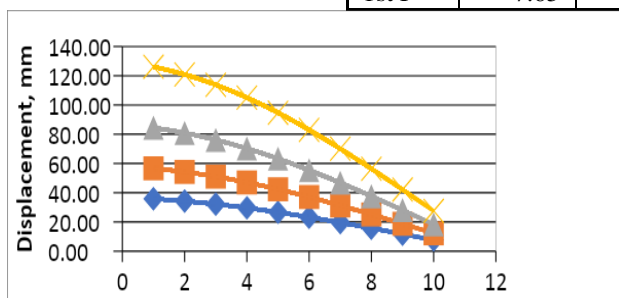


### STORY DISPLACEMENTS, MM FOR 1.0DL + 0.8LL + 0.8RSX IN X DIRECTION

Max story displacement in X Dir,

Table.1

Max Story Displacements in X Dir, mm				
Story	Zone II	Zone III	Zone IV	Zone V
Terrace	35.85	56.69	84.49	126.18
9th F	34.26	54.25	80.89	120.87
8th F	32.18	51.01	76.13	113.80
7th F	29.63	47.03	70.23	105.04
6th F	26.65	42.35	63.29	94.70
5th F	23.29	37.07	55.43	82.97
4th F	19.63	31.28	46.80	70.09
3rd F	15.75	25.12	37.61	56.36
2nd F	11.74	18.75	28.10	42.13
1st F	7.65	12.24	18.36	27.53



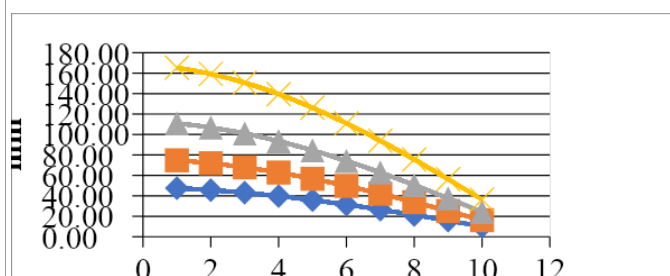
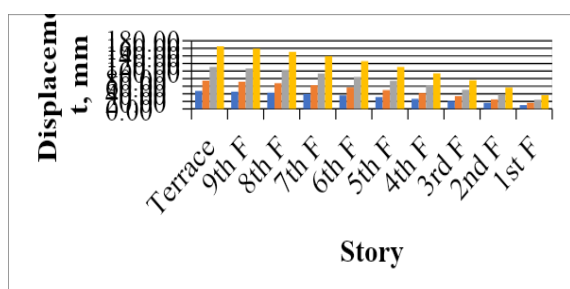
### IN Y DIRECTION

Table 2

Max story displacement in Y Dir,

Max Story Displacements in Y Dir, mm				
Story	Zone II	Zone III	Zone IV	Zone V
Terrace	47.57	74.75	110.99	165.34
9th F	45.68	71.89	106.84	159.27
8th F	43.06	67.89	100.99	150.64
7th F	39.77	62.79	93.48	139.53
6th F	35.86	56.70	84.49	126.17

5th F	31.43	49.76	74.20	110.87
4th F	26.54	42.09	62.82	93.91
3rd F	21.31	33.84	50.54	75.59
2nd F	15.82	25.15	37.60	56.27
1st F	10.17	16.20	24.25	36.31

**STORY DRIFT, MM FOR 1.0DL + 0.8LL + 0.8RSX**

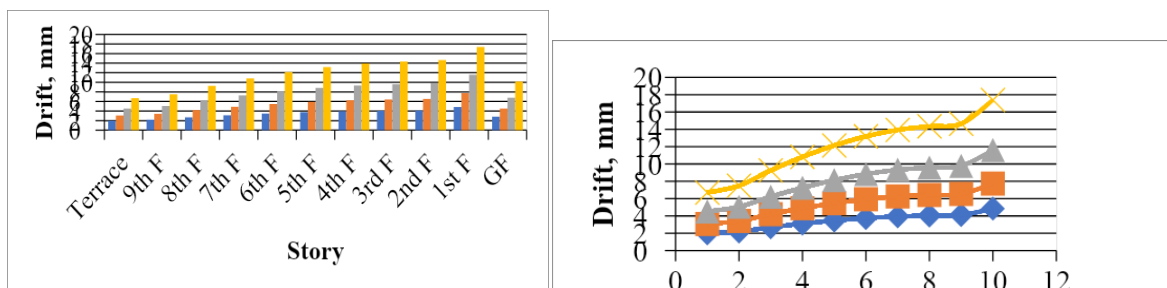
The storey drift is obtained from modelling by Response spectrum analysis are shown in tables and graphically represented

**IN X DIRECTION****Table 3**

Max Story Drift in X Dir, mm				
Story	Zone II	Zone III	Zone IV	Zone V
Terrace	1.981	3.068	4.516	6.689
9th F	2.2	3.42	5.048	7.49
8th F	2.684	4.199	6.22	9.251
7th F	3.11	4.888	7.258	10.813
6th F	3.467	5.467	8.133	12.132
5th F	3.748	5.925	8.829	13.185
4th F	3.942	6.249	9.324	13.937
3rd F	4.039	6.417	9.587	14.342
2nd F	4.103	6.535	9.779	14.644
1st F	4.839	7.733	11.593	17.383
GF	2.823	4.517	6.778	10.169

Story drift in X Dir,

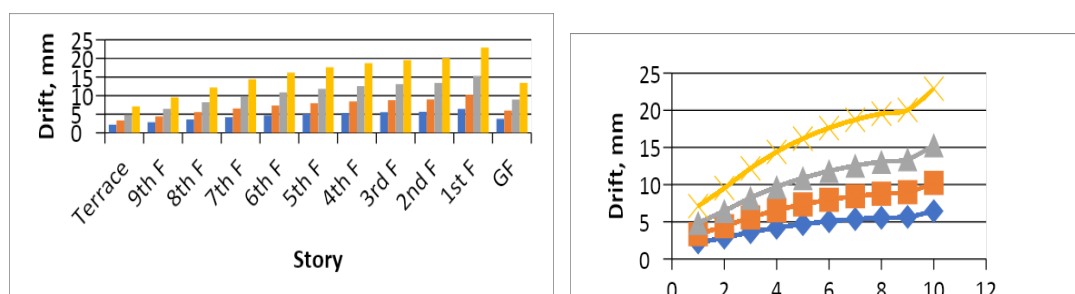




## IN Y DIRECTION

Table 4 Max story drift in Y Dir,

Max Story Drift in Y Dir, mm				
Story	Zone II	Zone III	Zone IV	Zone V
Terrace	2.202	3.335	4.845	7.109
9th F	2.862	4.401	6.453	9.53
8th F	3.592	5.575	8.219	12.185
7th F	4.198	6.552	9.69	14.398
6th F	4.681	7.336	10.876	16.186
5th F	5.062	7.96	11.823	17.617
4th F	5.352	8.439	12.556	18.731
3rd F	5.55	8.776	13.078	19.531
2nd F	5.663	8.981	13.404	20.039
1st F	6.428	10.231	15.302	22.908
GF	3.759	5.986	8.958	13.417





## V. CONCLUSION

1. Base Reactions for same building are increasing as the seismic zone increases. zone II to III, Zone III to IV and Zone IV to V has increased by 0.091%, 0.121% and 0.181%.
2. Just like the base reaction, maximum story displacement is also increasing as the zone increases. zone II to III, Zone III to IV and Zone IV to V has increased by 36.77%, 32.89% and 33.04% in X direction & 36.36%, 32.65% and 32.87% in Y direction.
3. Maximum story drift is also increasing as the zone increases. zone II to III, Zone III to IV and Zone IV to V has increased by 35.43%, 32.06% and 32.49% in X direction & 33.97%, 31.16% and 31.85% in Y direction.
4. Story displacement, story drift and story forces are shown in graphs, tables and percentage differences in these values between two consecutive zone for better understanding.
5. From all the above graphs, tables and values it can be said that increasing is structure's movement is directly proportional to the zone factor. It has to be checked if the different analysis results are within the limits. If not, suitable measurements have to be taken to restrict these values within the permissible figures.

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